Synchrotron radiation identified human chemical fingerprints – a novel forensic approach

T.J. Wilkinson, D. L. Perry, M. C. Martin, and W. R. McKinney

Lawrence Berkeley National Laboratory, University of California, Berkeley, CA 94720

Synchrotron radiation x-ray fluorescence microprobe and infrared spectromicroscopy have been used to generate fundamental data and to analyze and visualize latent human fingerprints with the goal of developing an advanced forensic technique to identify complicated partial latent prints. The chemical composition of fingerprints (sweat) is well documented in medical literature, and techniques abound to identify and develop latent prints. However, no useable technique currently exists to produce a forensic analysis of the fingerprint chemistry, or to identify the latent prints of pre-pubescent children. Fingerprints are essentially a mixture of sweat-based electrolytes, oils, fatty acids, steroid precursors, wax esters, and water. In the case of young and pre-pubescent children, only aqueous electrolytes are present. Mapping of these electrolytes by means of x-ray fluorescence microprobe is discussed and detailed. IR band intensities and band intensity ratios for functional groups of chemical molecules that are inherent to the fingerprint system are discussed in the context of molecular species that can be identified by comparison to infrared spectra that have been reported previously in the literature for identified components.
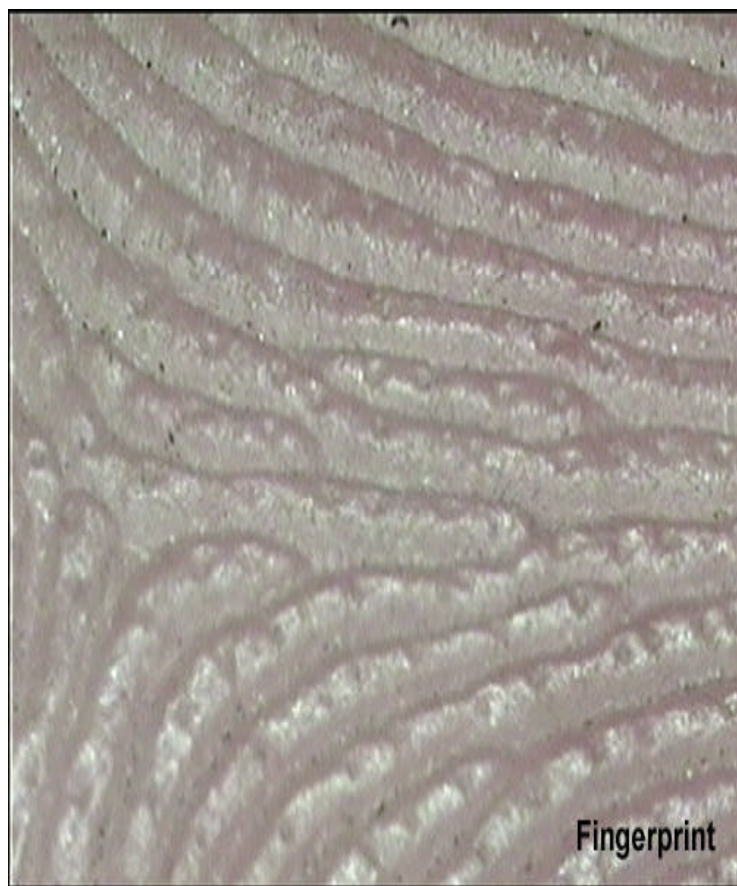
Figure 1. Close-up of a human fingerprint.

The fingerprints were analyzed using infrared beamlines 1.4.3 and 1.4.4 at the Advanced Light Source at Lawrence Berkeley National Laboratory. All spectra were obtained using collimated synchrotron light directed into either a Nicolet Continuum or Nicolet Nic-Plan 760 IR bench with microscope. The light is modulated by a moving mirror in a N_2 purged environment Michaelson FTIR interferometer and passed

into a Nicolet/Spectra-Tech IR microscope equipped with a mid-IR mercury cadmium telluride detector. For the purposes of this experiment, spectra were taken at 8 cm^{-1} resolution.

All samples were analyzed by collecting a minimum of 256 scans in the mid-IR range (4000-400 cm^{-1}). Residual water and CO_2 were subtracted, where appropriate, and baselines were normalized using correction routines present in the Nicolet software.

High purity paper was imprinted with human fingerprints and analyzed using Beamline 10.3.1 at the Advanced Light Source, Lawrence Berkeley National Laboratory. Beamline 10.3.1 is a scanning x-ray fluorescence microprobe for spatially resolved, high sensitivity elemental analysis. Sensitivity is in the femtogram range for most elements. Light focused by two bendable elliptical mirrors in the Kirkpatrick-Baez configuration illuminates a small 2- μm x 2- μm spot on the fingerprint sample. The mirrors are coated with multilayer reflectors to increase the reflectivity. A Si(Li) detector records the fluorescence x-rays, with the photon energy identifying the element and the intensity of its concentration. Scanning the sample through the beam builds up a distribution map for both majority and trace elements. In this experiment we specifically searched for elements present in human sweat.

Proof of concept has been made that the methods detailed here can be used to nondestructively identify and characterize fingerprints on a variety of materials. These techniques can be applied with use of synchrotron radiation (SR), but SR allows very small samples to be analyzed. The same procedures can be used for a variety of samples.

Principal investigator: Dale L. Perry, Lawrence Berkeley National Laboratory. Email: DLPerry@lbl.gov. Telephone: 510-486-4819.